Impact of FORMOSAT-7/COSMIC-2 on Ionospheric Space Weather Monitoring

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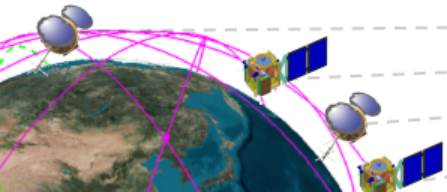
- Mission Description
- Observing System Simulation
- Impact on Ionosphere Monitoring
- Ionospheric Data Assimilation
- Conclusion



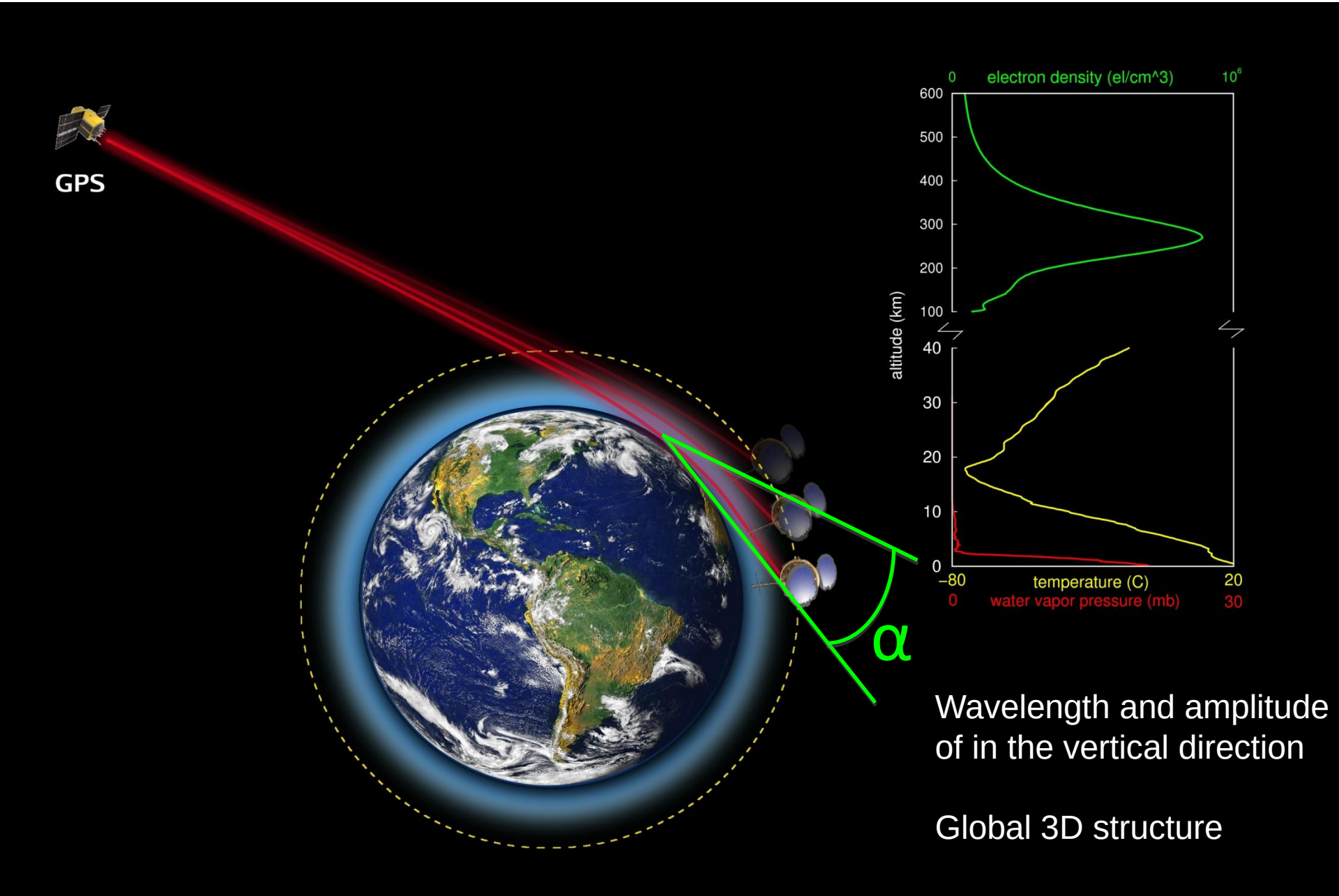
FORMOSAT-3/COSMIC

- ***FORMOSAT-3/COSMIC Constellation was launch at 01:40 UTC, April 14, 2006 (Taiwan Time: April 15 2006) at Vandenberg Air Force Base, CA.***
  Minotaur Launch

- ***Maneuvered into six different orbital planes (inclination ~72°) for optimal global coverage (at ~800 km altitude).***

- ***Five out of Six satellites are in good health and providing science data.***

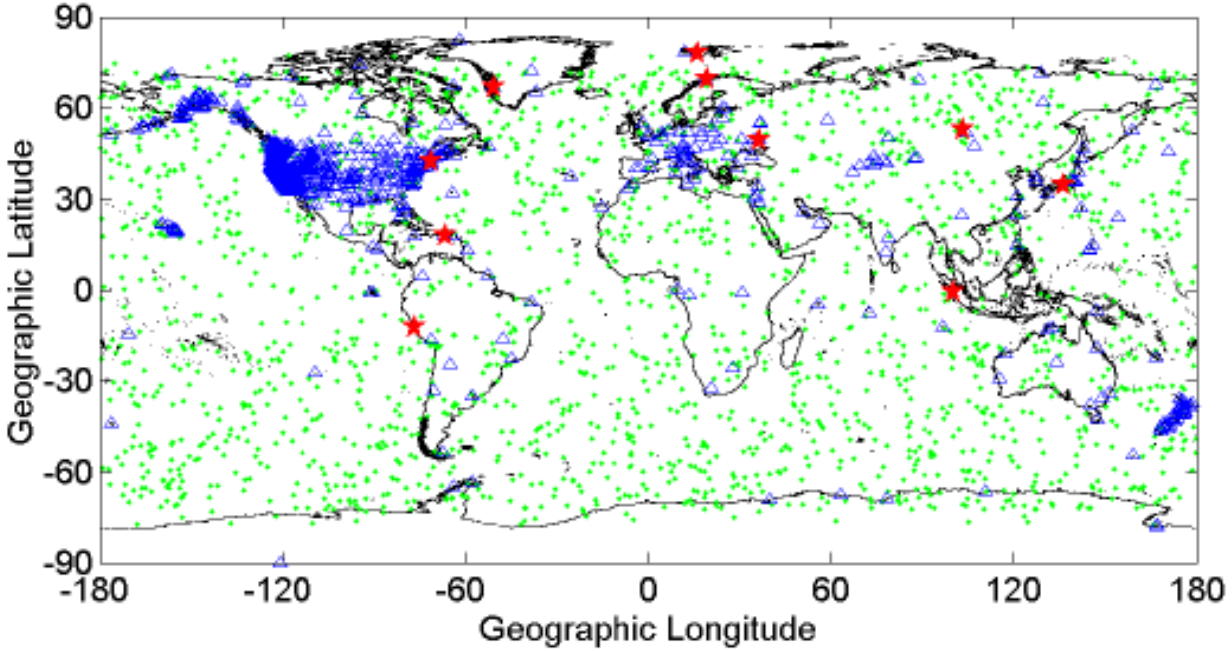
GPS Radio Occultation



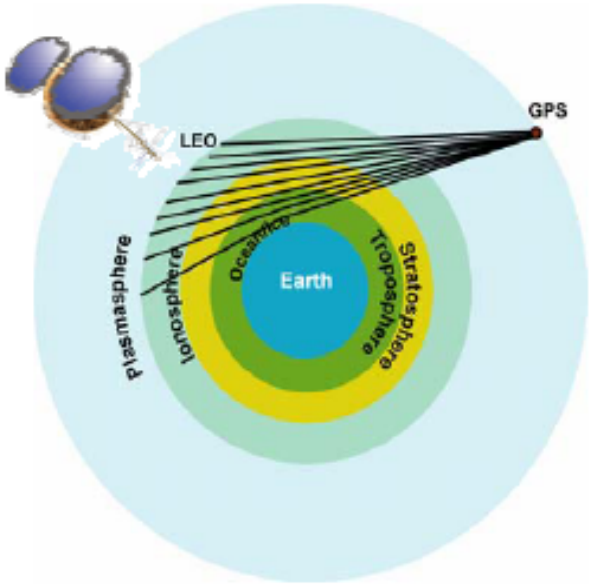
Wavelength and amplitude of in the vertical direction

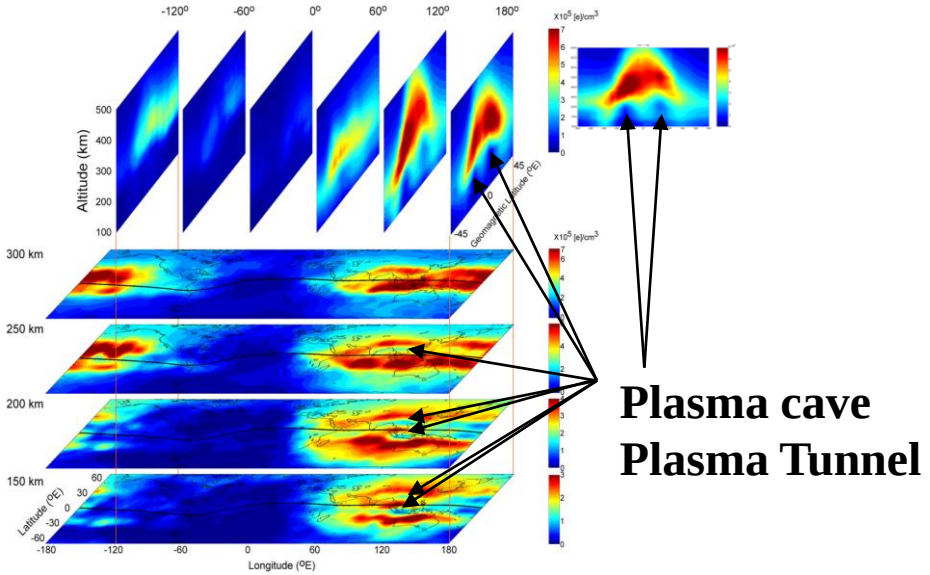
Global 3D structure

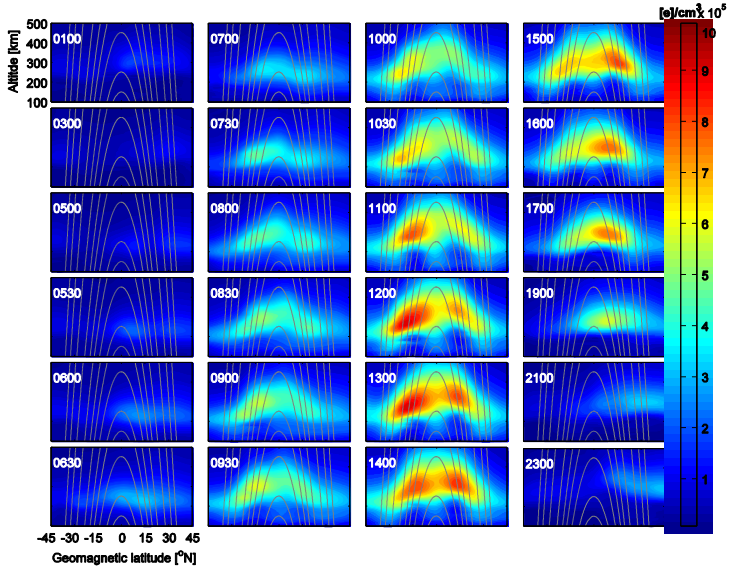
Distribution of occultation events observed by FORMOSAT-3



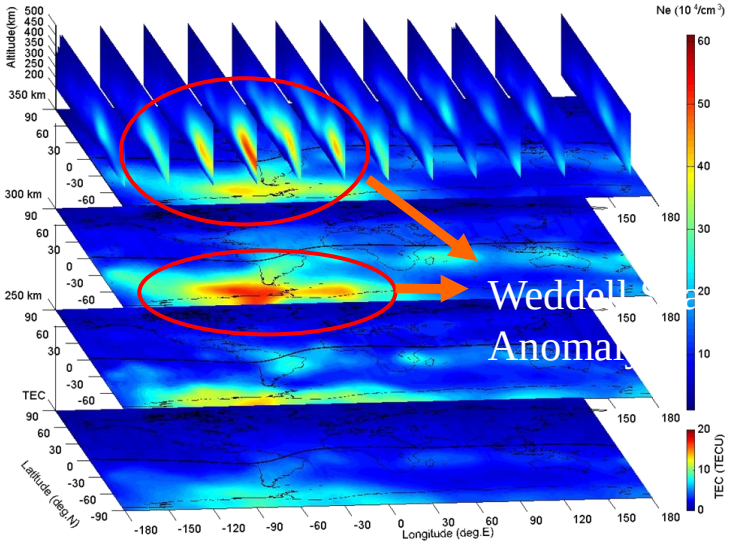
GOX

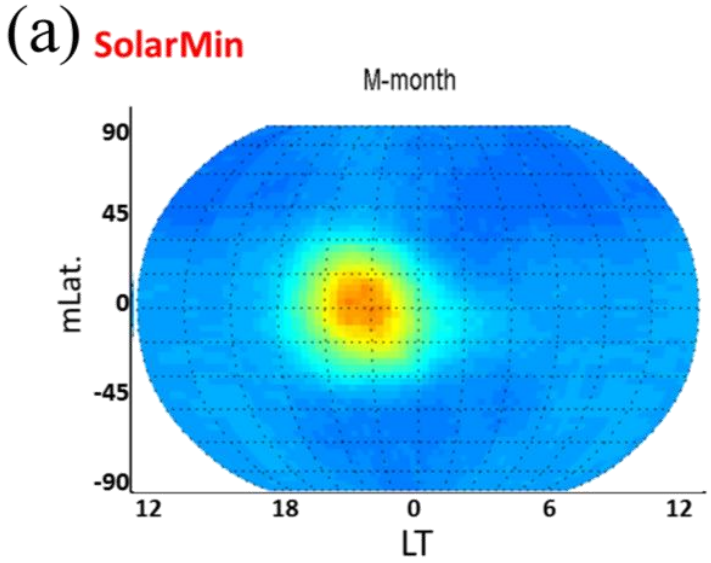


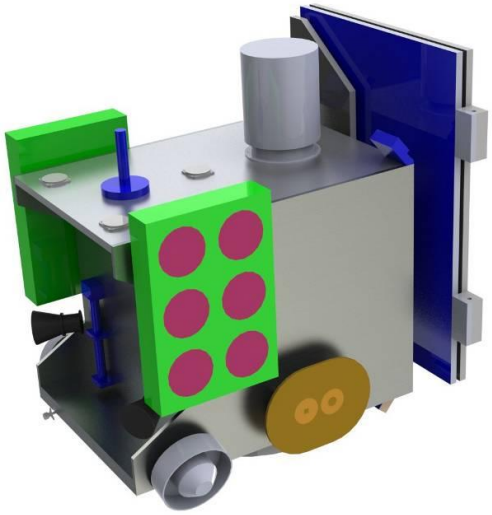




Ionospheric density distribution, signatures, and scintillation





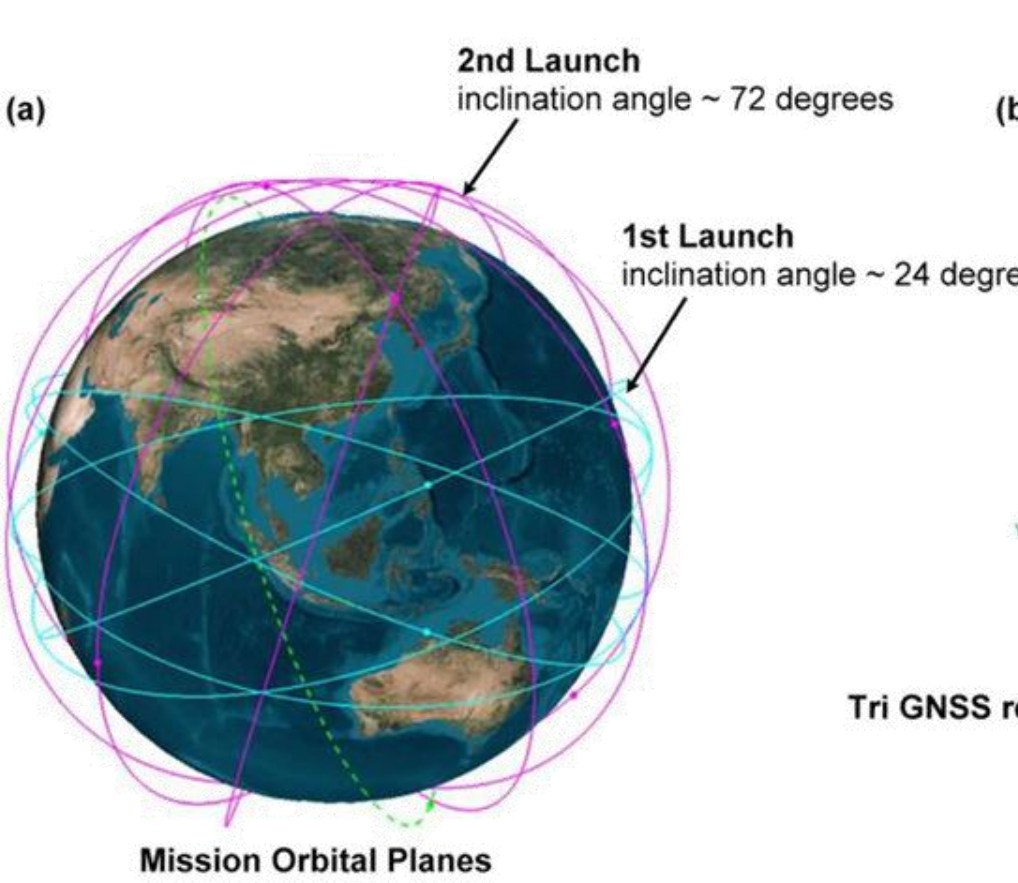


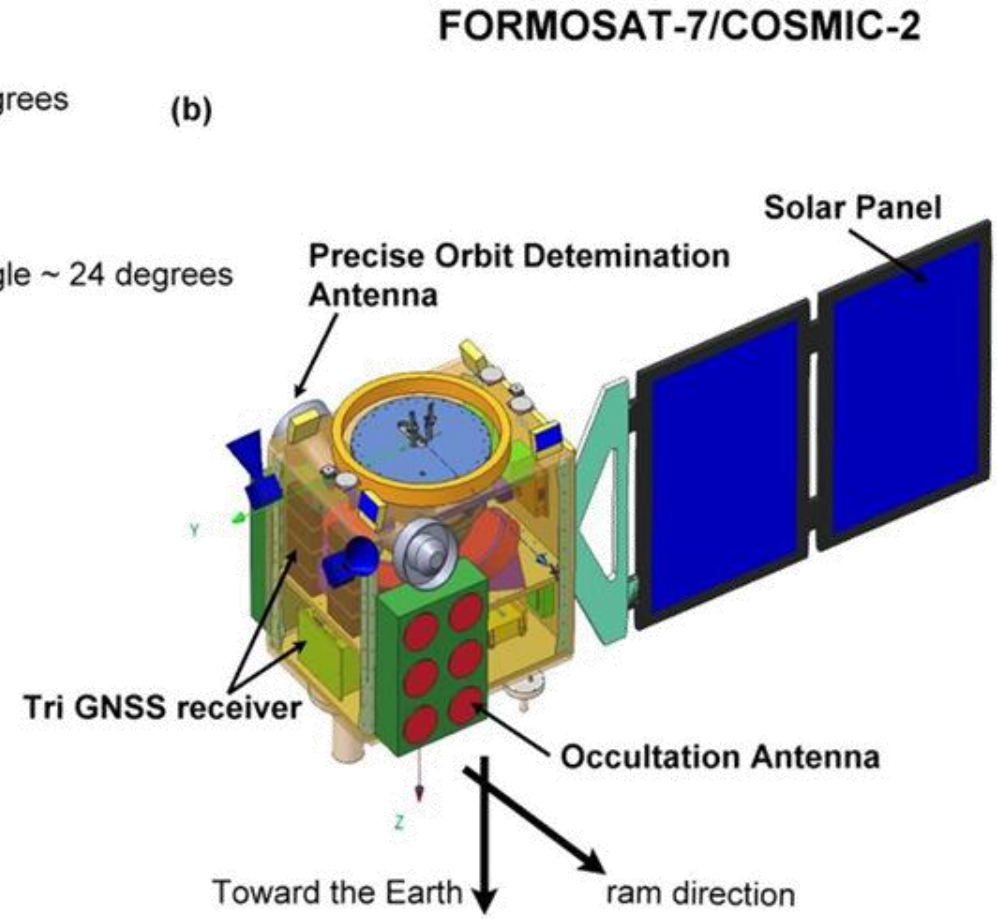
FORMOSAT-7 Program

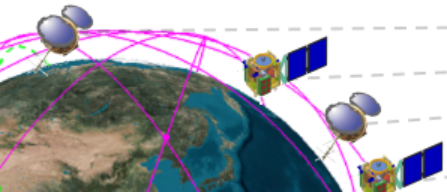
Global Real-time
Weather (Meteorology)
Space Weather (Ionosphere)
Observation and Prediction

The FORMOSAT-7 Program is a Taiwan-U.S. collaboration mission between NSPO (National Space Organization) of Taiwan and the NOAA (National Oceanic and Atmospheric Administration) of the United States. The objective of the FORMOSAT-7 Program is to deploy an extended 12-satellite constellation to continue the FORMOSAT-3 Program to measure atmospheric and ionospheric soundings. Data from the satellites will be made freely available to the international scientific community in near real-time.

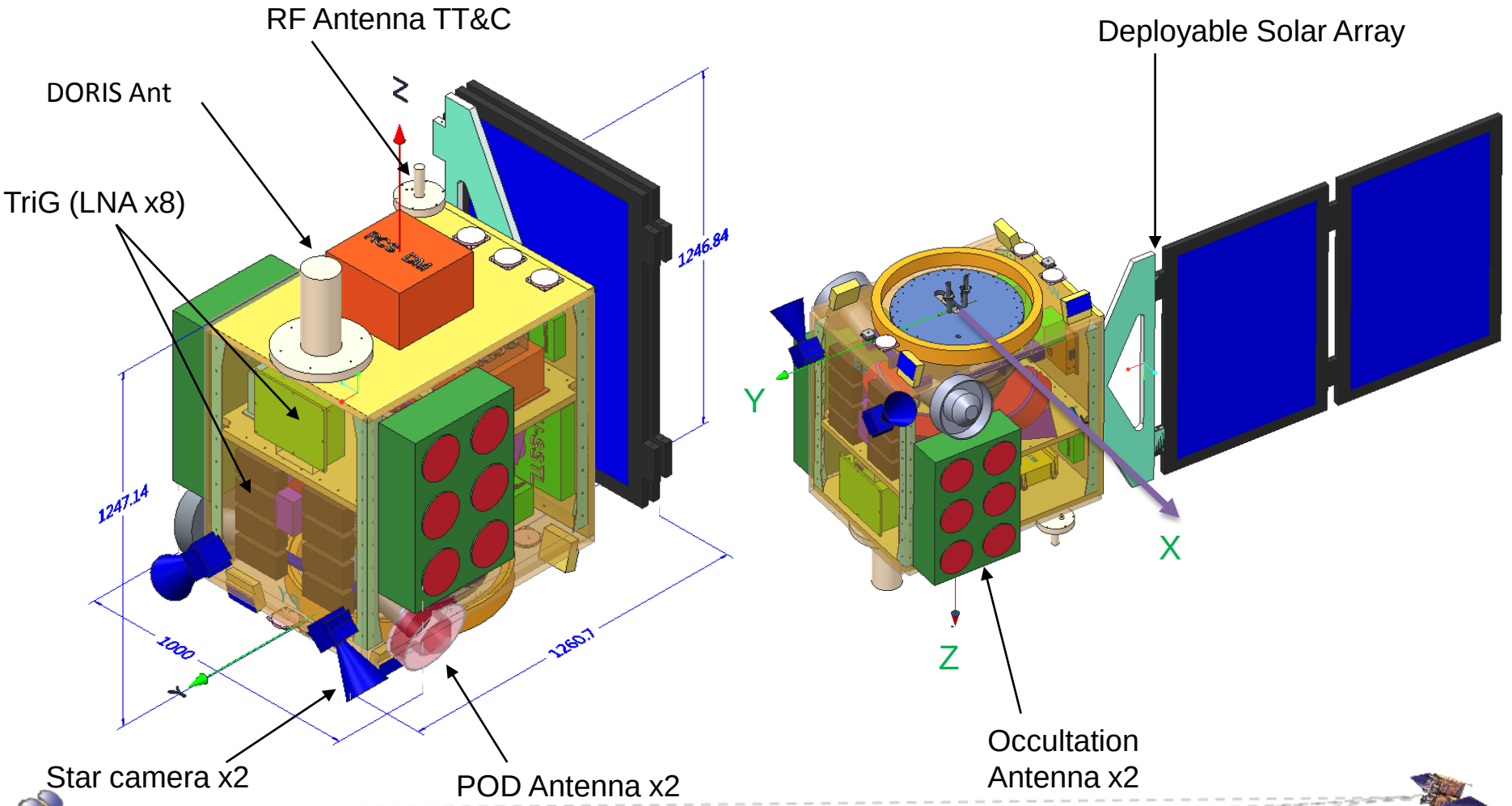
FORMOSAT-7 Program

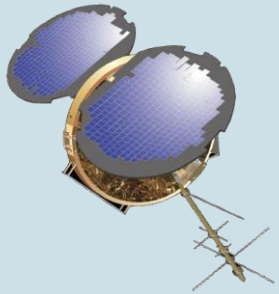
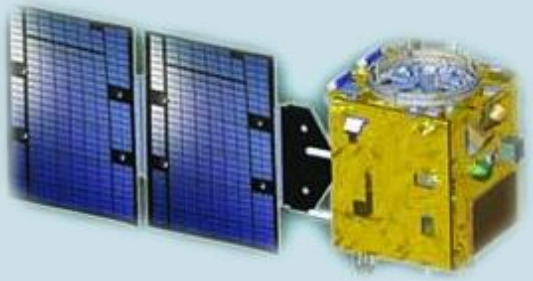


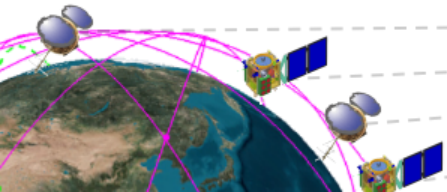


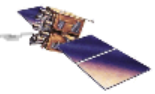


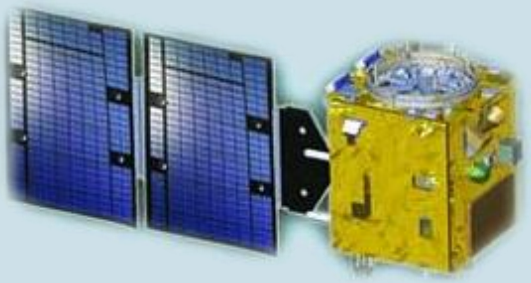
Configuration Overview

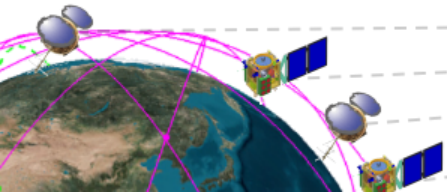


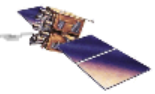
	FORMOSAT-3	FORMOSAT-7	
Exterior Design			
Sequence		1st Launch	2nd Launch
Constellation	6	6 Mission Satellite	6 Mission Satellite + 1 NSPO-Built Satellite
Mission Orbit Altitude	800 km	520-550 km	720-750 km
Inclination Angle	72°	24-28.5°	72°
Mission Payload	GOX	TriG	
RO Signals	GPS	GPS, GLONASS, Galileo	



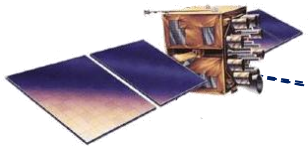


	FORMOSAT-7	
Exterior Design		
Sequence	1st Launch	2nd Launch
Science Payload	U. S. Science Payloads: 1.Radio Veacon Frequency Instrument 2.Ion Velocity Meter	Taiwan Science Payload: Selection Criteria: 1.Radio Occultation Enhancement 2.Constellation operations 3.Heritage Design
Data Product & Format	Same as FORMOSAT-3	
Launch Schedule	2016	2018 (TBD)



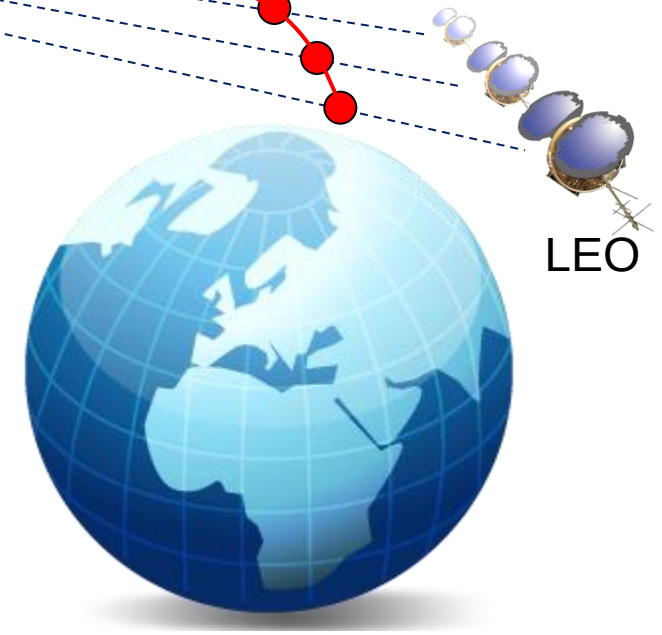


Observing System Simulation



GNSS

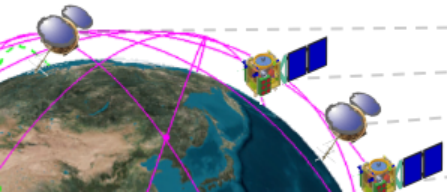
Tangent points

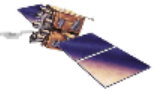


LEO

1. Predicting **occultation events** of F7/C2 which receiving signals from 28 GPS and 24 GLONASS satellites with one second sampling rate, based on the geometry between F7/C2 and two GNSS systems.
2. Estimating tangent point position of occultation events stand for the electron density profile locations of F7/C2.
3. The profile locations of F3/C corresponding to **real retrieved profiles** which were collected on 8 April 2008.
4. The profile locations of F3/C and F7/C2 are used to extract electron density values from model simulation to serve as synthetic observations.

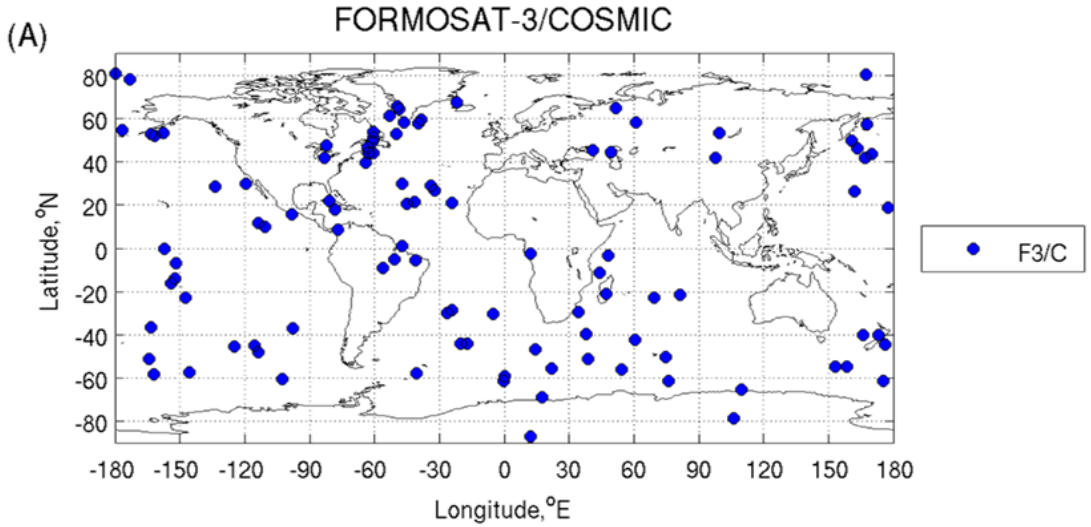
Notices: number of occultation events ≠ number of profiles





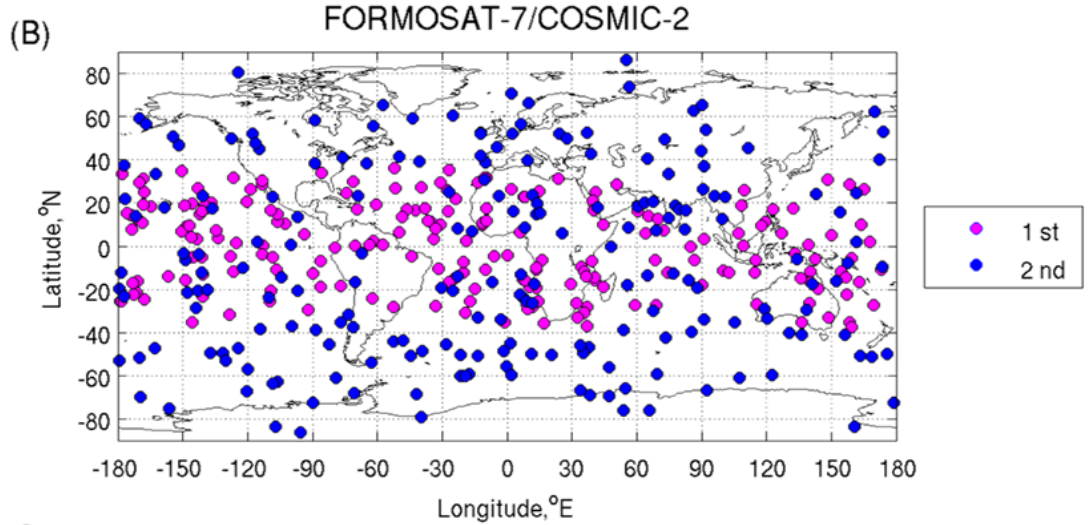
FORMOSAT-3 & FOMORSAT-7

FORMOSAT-7 vs. FORMOSAT-3



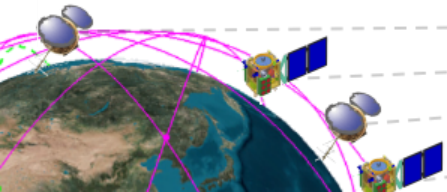
With 6 satellites + GPS, 60 minutes

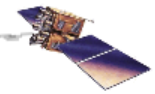
About 80-100 profiles per hour



With 12 satellites + TriG, 60 minutes

About 400 profiles per hour





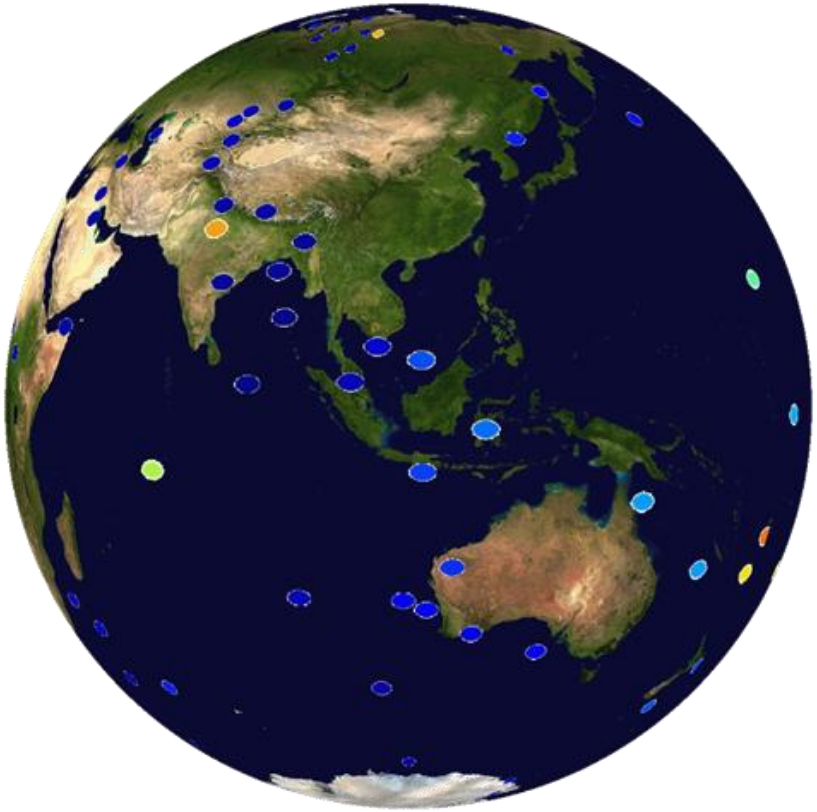
FORMOSAT-3 & FOMORSAT-7

FORMOSAT-3

Time: 00:00UT

Occ. Profiles: 089

(Real)

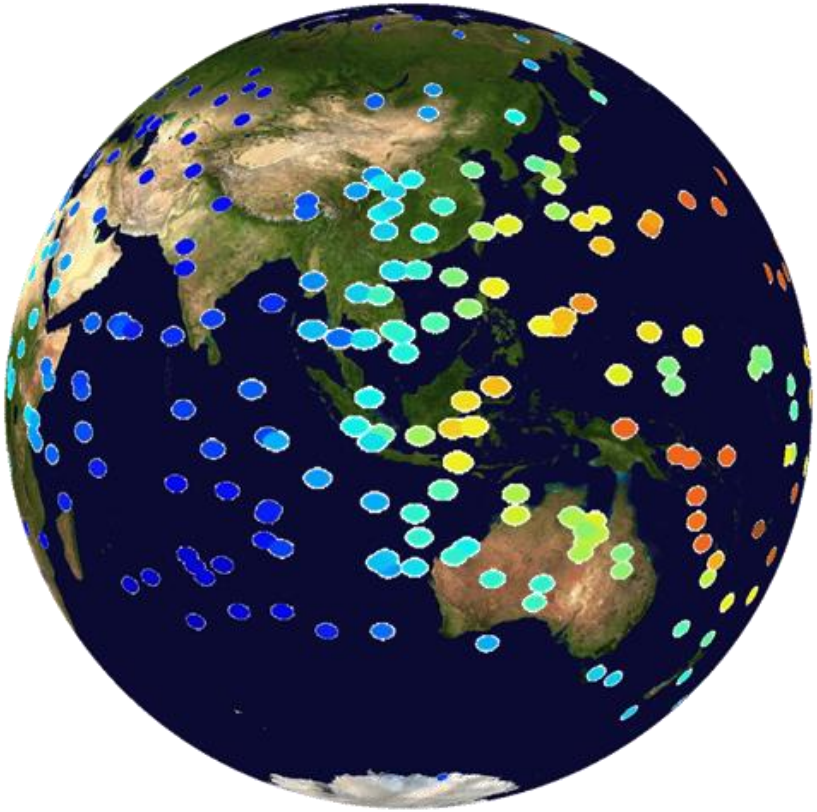


FORMOSAT-7

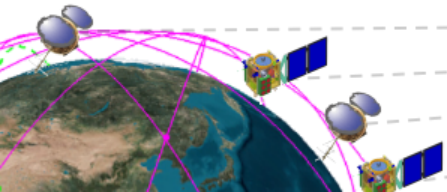
Time: 00:00UT

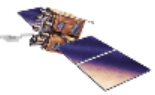
Occ. Profiles: 629

(Simulation)



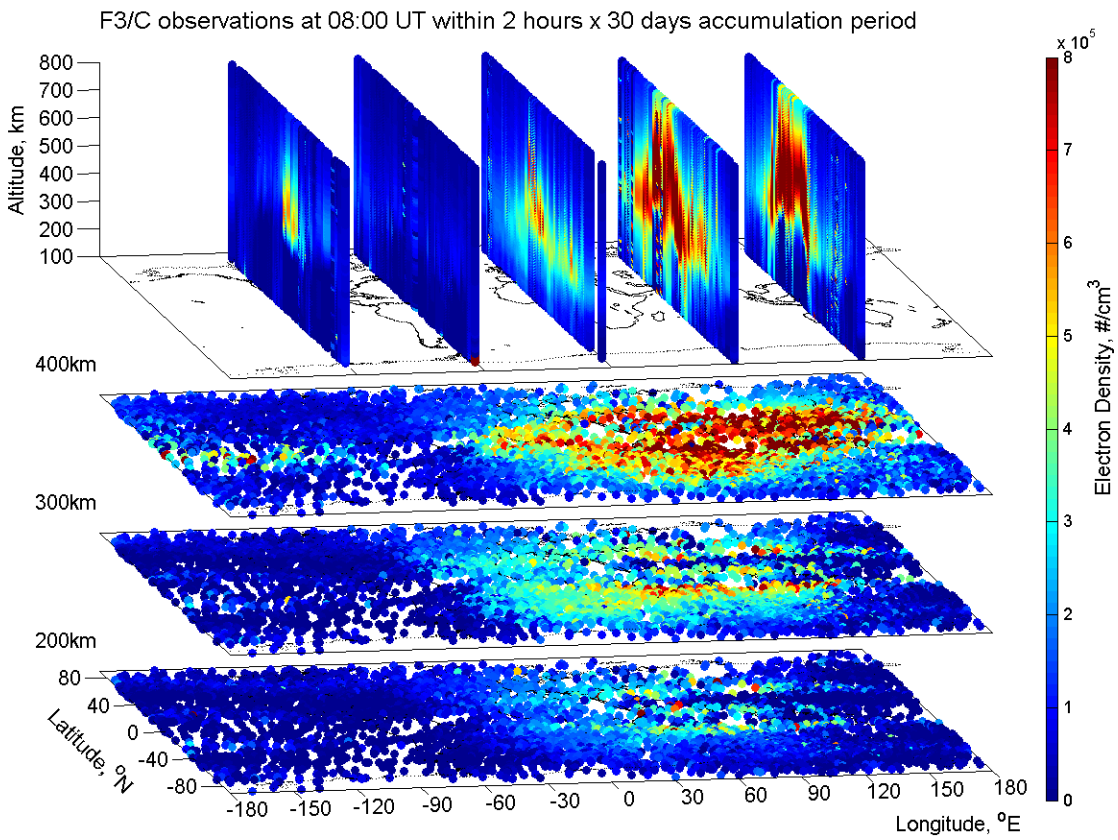
Colors of dots indicate electron density of foF2.





FORMOSAT-3 & FOMORSAT-7

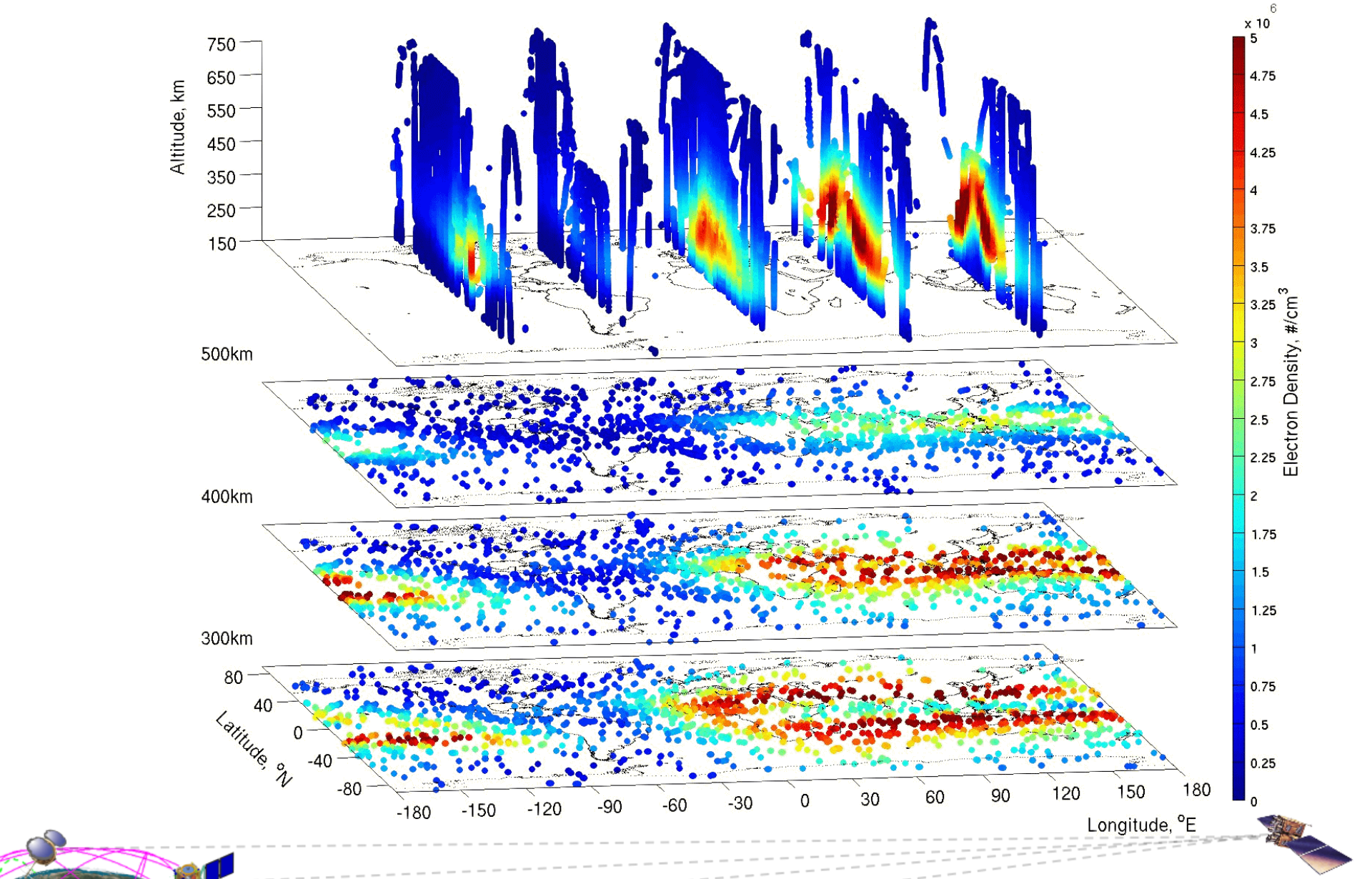
Ionospheric Weather Monitoring



Latitudinal slices are at -120˚, -60˚, 0˚ 60˚ and 120˚ longitude with a interval of ±2.5˚.

- Solar activity variations
- Seasonal variations
- Monthly variations
- Tidal effects
- Diurnal variations
- Semi-diurnal variations
- Disturbed period effects
- Other temporal variations
- Irregularities

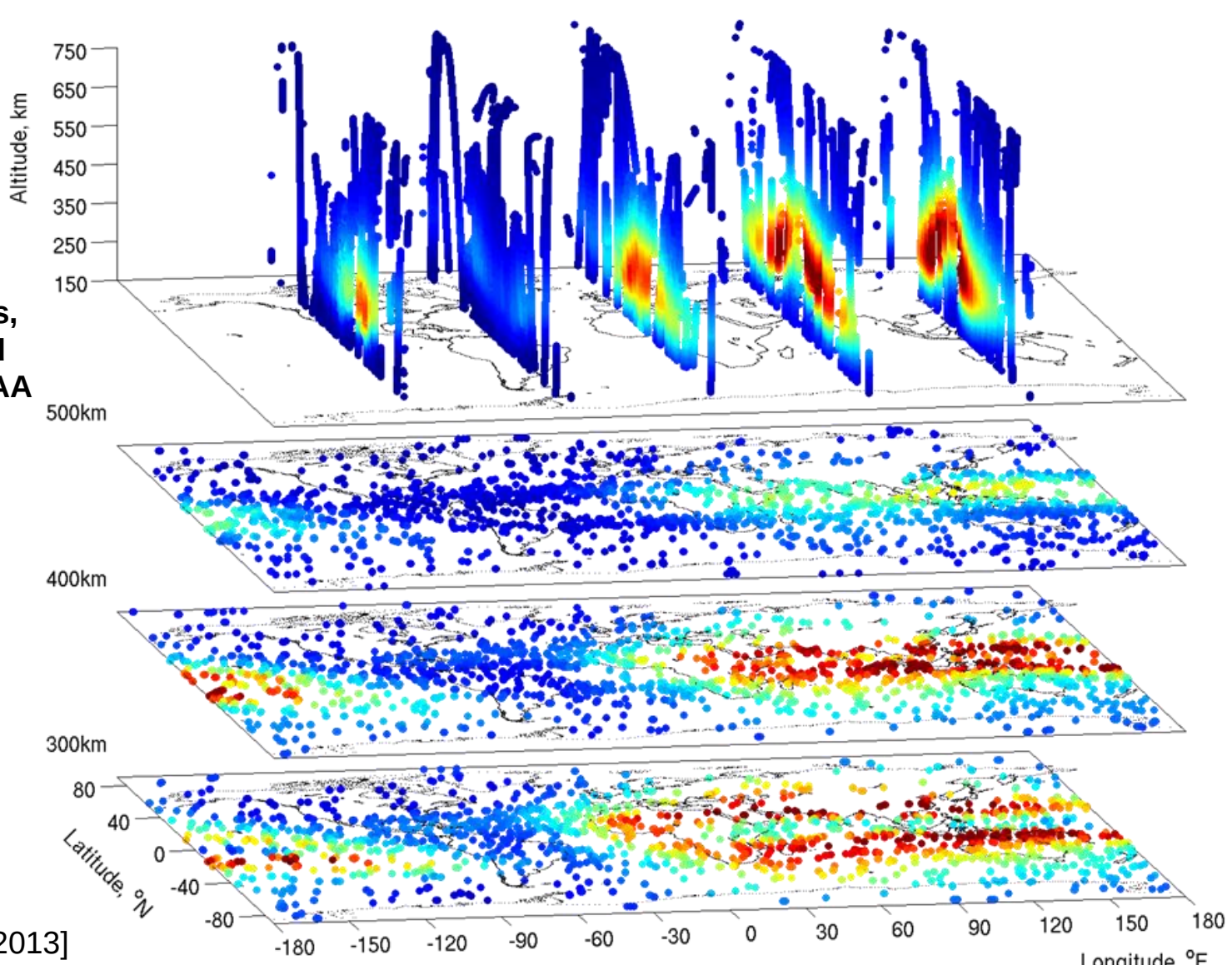
Could it be advanced by F7 ?



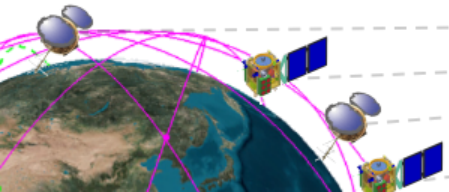
FORMOSAT-3 & FOMORSAT-7

Simulated F7 observations at 08:00 UT within 1 hour x 1 day accumulation period

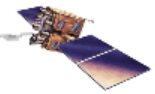
12 satellites,
28 GPS and
24 GLONAAA



Lee et al. [2013]

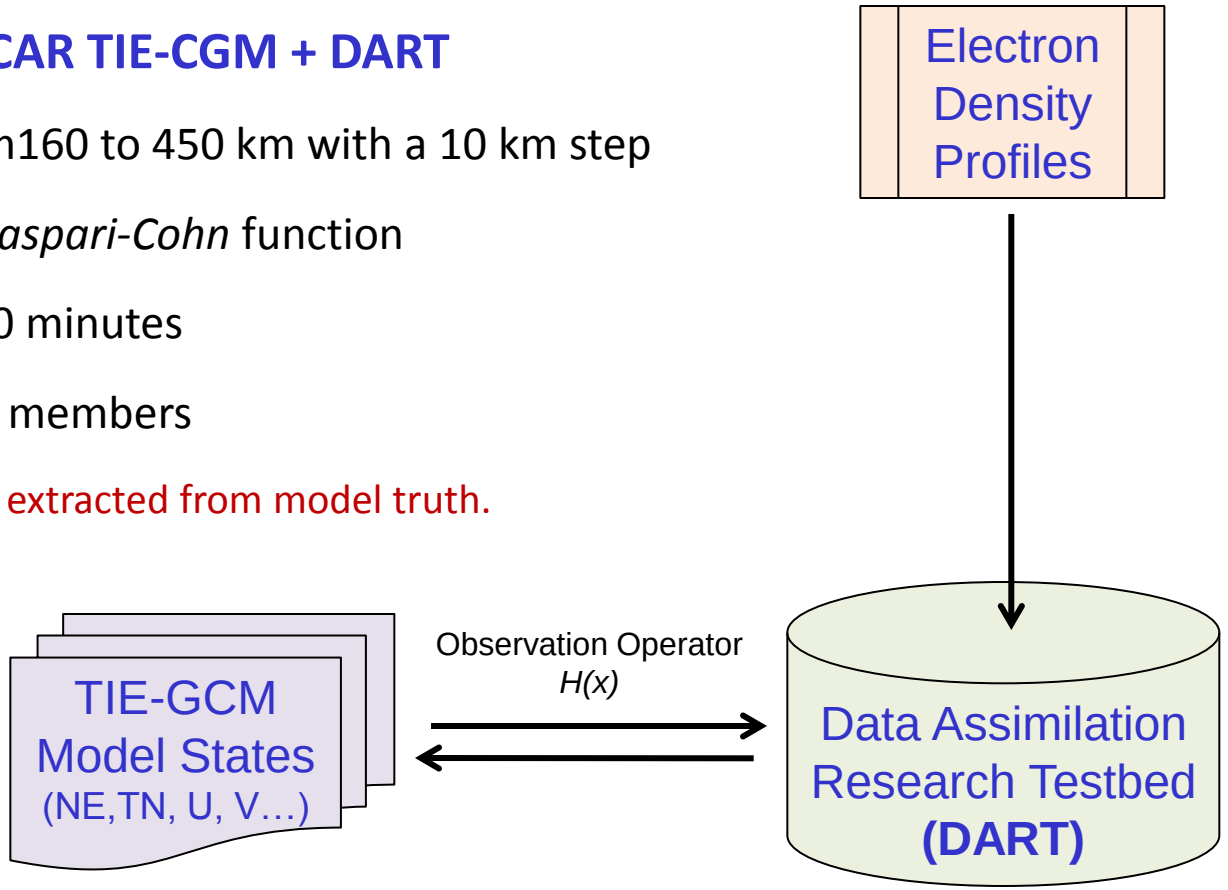


FORMOSAT-3 & FOMORSAT-7

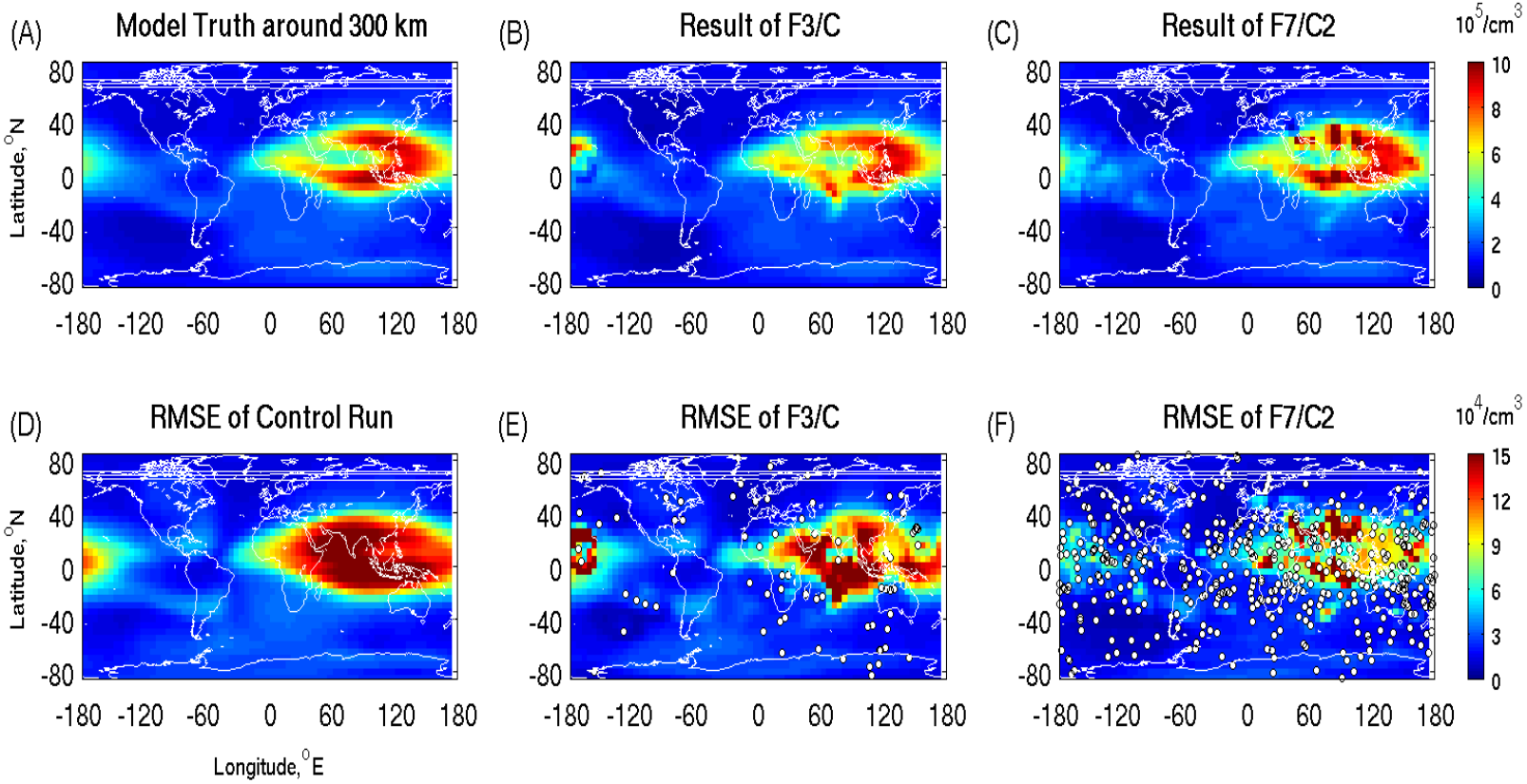


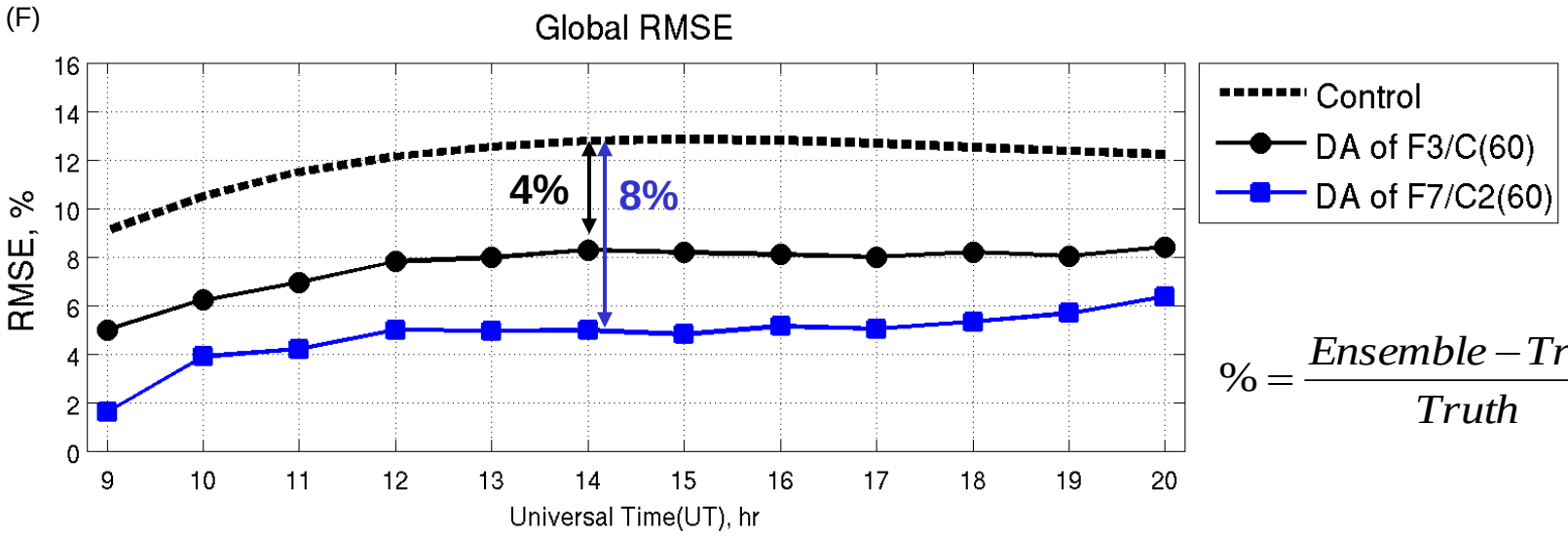
Ionospheric Data Assimilation

- Period: 09:00 UT –20:00 UT
- Assimilation System: **NCAR TIE-CGM + DART**
- Observation range: from160 to 450 km with a 10 km step
- Localization function: *Gaspari-Cohn* function
- Assimilation window: 60 minutes
- Ensemble members: 90 members
- Synthetic observations are extracted from model truth.



Matsuo and Araujo-Pradere [2011],
Lee et al. [2012, 2013],
Matsuo et al. [2013],
Hsu et al. [2014]



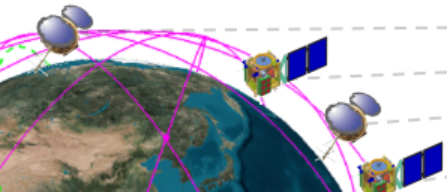


$$\% = \frac{Ensemble - Truth}{Truth} \times 100$$

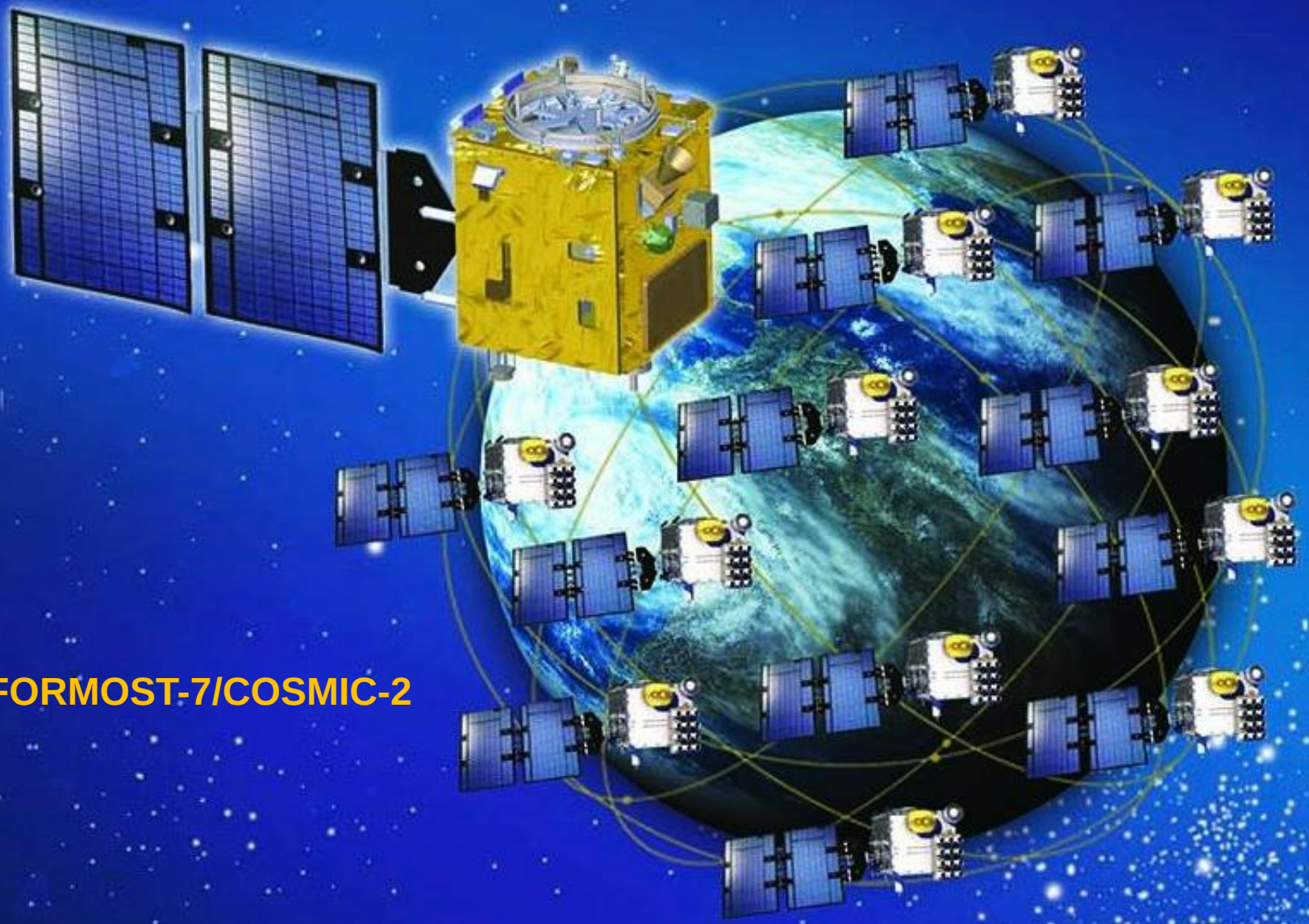
SAT-7

Summary

- FORMOSAT-7 satellites will daily provide nearly 12,000 occultation events which is about four times more than that provided by the F3/C mission.
- FORMOSAT-7 allows for the capability to reconstruct the 3D ionospheric electron density structures for ionospheric space weather monitoring within a dramatically short data accumulation period.
- FORMOSAT-7 will open a new chapter and have an especially significant impact on the ionospheric weather monitoring, greatly benefitting the ionospheric date assimilation for future space weather forecasting.



Thank You for Your Attention.



FORMOST-7/COSMIC-2